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The Investment Decision

A Re-Examination of Competing Theories Using Panel Data

Cherian Samuel

For firms, the single most important determinant of capital spending appears to be cash flow. Firm managers care more about cash flow and cost of capital than about stock market signals and level of output.

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Summary findings

In the United States, gross business investments in plant and equipment (fixed investments) constitute only about 10 percent of GNP, but such investments may represent GNP's most important component because (1) plant and equipment have a long-term effect on the economy's productive capacity, (2) changes in investment spending directly affect levels of employment and workers' incomes in durable goods industries, and (3) supply and demand are sensitive to changes in investment, which is the most volatile component of GNP.

Economists have long been concerned about what — in the economy, the industry, and the firm — determines investments in capital spending. Using a panel of data for U.S. manufacturing firms for 1972–90, Samuel compares five theories of investment: accelerator theory, cash flow theory (liquidity model, managerial model, and information-theoretic model), neoclassical theory, modified neoclassical (Bischoff) theory, and Q theory.

If the results from cross-section regressions can be viewed as representing the long-term equilibrium, the single most important determinant of capital spending appears to be cash flow.

Apparently, managers care more about cash flow and cost of capital than about stock market signals and the level of output. And at the firm level, managerial perceptions about fundamentals are more important than market perceptions. For managers, the stock market may be a side show to capital spending decisions.

To generalize in a way that might be useful for developing countries: Financial decisions at the firm level are closely linked to real decisions in the economy. Internal finance is the most important source of funds, and capital spending is the most important use of funds, so there is a close relationship betwen real and financial decisions.

This paper — a product of the Operations Policy Group, Operations Policy Department — is part of a larger effort in the department to disseminate results of policy analysis. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Cherian Samuel, room MC10-362, telephone 202-473-0802, fax 202-522-3253, Internet address csamuel@worldbank.org. September 1996. (51 pages)

The Investment Decision: A Re-examination of Competing Theories Using Panel Data*

CHERIAN SAMUEL

Operations Policy Group

Operations Policy Department

World Bank

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The Investment Decision: A Re-examination of Competing Theories Using Panel Data

Even though business expenditures on plant and equipment gross investment (business fixed investment) in the United States constitute only about 10% of GNP, it is still perhaps the most important component of GNP because: (i) plant and equipment are durable goods and therefore variations in investment expenditures have long-term consequences for the economy's productive capacity; (ii) investment expenditures affect demands for the products of the construction and producer's durable goods industries. Therefore, changes in investment expenditures lead to shifts in the aggregate levels of employment and personal income through both direct and indirect effects; and (iii) since investment is the most volatile component of GNP, aggregate supply and demand are very sensitive to changes in investment.

Given these considerations, economists have been concerned with the analysis of the determinants of investment (capital) expenditures for a long time. This analysis has been conducted at all levels of disaggregation viz. economy, industry, and the firm. This paper compares the alternative theories of investment using a panel of U.S. manufacturing firms for the 1972-1990 period.

The study is organized into four sections. Section I begins with a discussion of the alternative models of investment, then examines the empirical evidence for these models, and considers the policy implications of the different models. Section II reports the results of the time-series regressions. Section III has results from cross-section regressions. Section IV deals with fixed effects models. The final section concludes the study and discusses the implications for developing countries.

I

Models of investment

Broadly speaking, one can distinguish at least five theories of investment: (i) accelerator theory; (ii) cash flow theory; (iii) neoclassical theory; (iv) modified neoclassical (Bischoff) theory; and (v) Q theory.[1] Within the rubric of the cash flow theory, there are three variants: (a) liquidity model; (b) managerial model; and (c) information-theoretic model.

For analytical purposes, the alternative theories of investment can be classified in various ways. One division could be based on the optimal adjustment path for the firm's capital stock. While the accelerator, neoclassical, modified neoclassical, and the cash flow models do not explicitly consider the optimal adjustment path for the firm's capital stock when it is away from that level, the Q theory characterizes the complete evolution of the capital stock from the underlying optimization problem.[2] This therefore provides a rationale for expectational lags and leaves room for lags in delivery and installation only.

Another way to think about the different models of investment is to highlight the factors that underlay the marginal returns to investment and the marginal cost of finance in the different models. For instance, a sharp distinction can be drawn between the managerial and neoclassical theories of investment (Grabowski and Mueller (1972)). In the neoclassical theory, internal and external finance are perfect substitutes, following Modigliani-Miller(1956) theorems, and therefore the marginal cost of finance equals the shareholder's opportunity cost of capital. In the managerial theory of investment however, managers prefer to use internal funds since they are

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[1] See Appendix I for a description of these models.

[2] This feature is also present in the irreversibility models. See Dixit and Pindyck (1994) for a more detailed discussion of irreversibility models.

the most accessible part of the capital market and hence most malleable to managerial desires for growth. The marginal cost of capital is significantly lower for internal finance compared to external finance, and therefore not equal to the shareholder's opportunity cost of capital, but some much lower totally subjective value set by the managers. In equilibrium, marginal returns to investment equal the marginal cost of finance.

The alternative models of investment can also be classified in terms of the relative importance of price variables like taxes and interest rates, quantity variables like output and liquidity, and autonomous shocks like "animal spirits" and technology shocks as determinants of capital expenditures (Chirinko (1993)). For the neoclassical model, only price variables matter; for the accelerator and cash flow models, only quantity variables matter. For the Q theory, what is relevant is autonomous shocks, and for the modified neoclassical model, what matters is a combination of price and quantity variables, with the latter being somewhat more important.

These five basic models of investment are useful for a relative ranking of the various factors (output, cash flows, cost of capital, prices, technology shocks etc.) that are important in shaping investment decisions. In addition to these five models that emphasize the role of a single factor to the exclusion of all others in the determination of investment expenditures, one can think of at least two other composite models that are combinations of these basic models that emphasize a number of factors: (i) accelerator-cash flow; and (ii) Q-cash flow.[3] These composite formulations are essentially a recognition of the complexities involved in the

[3] Even the Bischoff (1971) model can be viewed as a composite model, i.e., the neoclassical-accelerator model.

investment process, the attempt being to capture the multitude of constraints that are operative with regard to capital expenditure decisions.

Like many other topics in economics, research on investment demand has been through its share of cycles over time. Thus, the early writers of the subject emphasized the accelerator approach (Clark (1917), Chenery (1952), Koyck (1954) and others). The original contribution of Clark (1917) was in fact part of an overall explanation for business cycles.

The next theory of investment to emerge was the liquidity (residual funds) theory (Dusenberry (1958), Meyer and Kuh (1957), Kuh (1963), Meyer and Glauber (1964), and Meyer and Strong (1990)). According to the liquidity theory, investment depends primarily on cash flows/internal finance--the sum of retained earnings and depreciation. In other words, investment may be constrained by the supply of internal funds. Past levels of profits may also be an adequate proxy for future levels and hence might be relevant for capital expenditures decisions.

In part, the liquidity theory can be viewed as an attempt to explain the existence of financing hierarchy, which constitutes one of the most well-documented facts of corporate finance (Koch (1943), Donaldson (1961)), wherein the firm's preferred ordering of the sources of finance is: (1) internal finance; (2) external debt; and (3) new equity. In fact, Donaldson (1961) found that firms sold cash and investments (marketable securities) before taking on external debt.

In the meantime, Grunfeld (1960) proposed the use of the firm's market value as a proxy for expected profitability. Therefore, investment depends on the market value of the firm. In a way, the market value approach of Grunfeld can be viewed as a sort of a precursor to Tobin's Q theory.

Then came along the neoclassical model formulation by Jorgensen (1963, 1966, 1967, 1971) and associates, in the wake of the Modigliani-Miller (1958) theorems. The neoclassical model of investment implies that investment decisions depend mainly upon the cost of capital, and that the real and financial decisions undertaken by the firm are separate. The departure of the Jorgensonian approach was also in providing a structural formulation of the investment decision, based on profit maximizing behavior by firms. The earlier approaches lacked an explicit theoretical basis and were even deemed ad hoc at one level.

About the same time, in a series of studies, Eisner and associates (1963, 1964, 1967, 1969, 1970, 1978) revived the accelerator approach, adding profits as well to the investment equation. Therefore, it is probably more accurate to characterize the Eisner model as the accelerator-profits model. Without surprise, a serious debate emerged between Jorgensen and Eisner regarding the relative merits of neoclassical and accelerator models of investment. Professional economic journals of the late 1960s and the early 1970s are littered with these debates.

The Q theory of investment, due to Brainard and Tobin (1968) and Tobin (1969), was in sharp contrast to the output-oriented models discussed above in that it attempted to explain investment on a financial basis in terms of portfolio balance, i.e., based on the q ratio--the ratio of the market value of capital to its replacement cost. If managers seek to maximize the market value of firms, they will add to their capital stock whenever the marginal addition to the firm's market value exceed the replacement cost of the capital stock.

Bischoff (1971) proposed an important extension to the standard Jorgensonian neoclassical model with the putty-clay approach. i.e., Bischoff (1971) pointed out that it is often easier to modify factor proportions and thus the capital-output ratio ex ante; ex post, the substitution between factors is zero. Consequently, investment may be more responsive to changes in output compared to changes in the cost of capital. In other words, the distributed lag of investment on changes in the relative prices of capital services has a different shape from the distributed lag of investment on changes in output. In the literature, this model is known as the modified neoclassical model.

In a broad sense, the managerial and the information-theoretic approaches to investment, that are currently in vogue, can be viewed as modern versions of the liquidity theory. Both approaches emphasize the role of internal finance as the fundamental determinant of investment decisions. i.e., Both theories predict a positive relationship between cash flows and investment.

In the information-theoretic view, internal and external finance are not substitutes because of information asymmetries between insiders and outsiders. In the managerial view, internal finance is preferred since it facilitates discretionary behavior by managers that may run counter to the interests of the shareholders. Managers may pursue goals that are separate from the welfare maximization of shareholders, either through the pursuit of growth maximization or through the excessive consumption of perquisites.[4]

In a chronological sense, the managerial approach to investment predates the information-theoretic approach. While the managerial theory of the firm is due to Marris (1963, 1964), the

[4] See Samuel (1996a) for a more detailed discussion of the managerial and information-theoretic approaches. The original thesis of separation of ownership and control (management) is due to Berle and Means (1932).

formal modelling and testing of the managerial theory of investment came with Grabowski and Mueller (1972). The information-theoretic approach to investment is really an off-shoot of Akerloff's (1970) paper on the market for lemons. Akerloff (1970) showed that information asymmetries could interfere with the normal functioning of markets and could lead to their breakdown. The problems could be particularly acute in some markets.

Stiglitz and Weiss (1981) and Myers and Majluff (1984) proposed important applications of the lemons framework to the study of equity and loan markets. They pointed out that information asymmetries could also lead to credit rationing and explain the existence of the financing hierarchy. In fact, Greenwald et al. (1984) argued that under conditions of credit rationing, it is the availability of capital rather than the cost of capital that matters for investment decisions.

As far as composite models go, the accelerator-profit (cash flow) model is due to Eisner (1978) and others. In the Eisner model, gross capital expenditures is a function of sales, depreciation, and profits. Eisner (1978) argued that the rate of expected output should be the primary determinant of investment. In practice, this translates to formulating investment as a distributed lag function of current and past changes in sales. Other forces influencing the expected profitability of investment is captured in current and past profits, which may also capture some capital supply effects. i.e., To the extent that capital markets are imperfect, firms tend to invest more when profits are high and less when profits are low.

In the empirical literature, the Q-cash flow model has been motivated by at least two strands of research: (i) the information-theoretic approach to the study of investment (Fazzari et al. (1988)); and (ii) the study of managerial perception versus market valuation factors in investment decisions (Blanchard et al. (1993), Rhee and Rhee(1991)).

Fazzari et al. (1988) estimate a reduced form investment equation with cash flows and the q ratio as the independent variables. One criticism against this reduced form approach has been that cash flows may proxy investment demand even if the q-ratio, the supposed proxy for investment demand, is included in the regression. Poterba (1988), for instance, notes that if measured (average) q is a poor proxy for the true marginal q, it could be that cash flows and true (marginal) q are also correlated. This could also lead to simultaneity bias in the estimation process.

Blanchard et al. (1993) consider the role of the stock market as a signal to managers with regard to investment decisions. The issue here is whether managers take cognisance of the signals given by the stock market or by the q ratio, while undertaking capital expenditure decisions, even if the market valuation does not match their own valuations or perceptions of fundamentals.[5]

In any case, from a purely statistical/econometric point of view, the composite models can be expected to perform better than the basic models in that the former regressions include more independent variables. However, the empirical evidence presented in this paper is limited to the five basic models of investment discussed above.

Empirical evidence

The validity of any model of investment is ultimately judged by its ability to explain past data as well to make future predictions. In two separate studies, Jorgensen and Siebert (1968a,

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[5] See Samuel (1996b) for a detailed discussion and empirical evidence.

1968b) carried out detailed empirical testing of competing models--accelerator, neoclassical, liquidity, and market value--at the firm-level and found the neoclassical model to be the best. The Jorgensen and Siebert sample consisted of fifteen large manufacturing firms for the 1949-1963 period.[6]

However, Elliott (1973) re-estimated the models of the original Jorgensen sample and came to quite different conclusions. Elliott's sample consisted of 184 firms for the 1947-1963 period. In cross-section estimates, cash flow model was found to be the best, while in time-series estimates, the accelerator model was better than all others. In general, Elliott's results nullified Jorgensen's results for the neoclassical model and confirmed the need to have a more eclectic framework towards understanding investment decisions by firms.

As noted earlier, Eisner's studies consistently indicated the superiority of the accelerator/accelerator-cash flow models compared to the neoclassical model of investment. Grabowski and Mueller (1972) carried out a testing of the managerial and stockholder welfare (neoclassical) models of firm expenditures using data for 66 firms for the 1959-1966 period. Their empirical results indicated the managerial variant of the model to be far superior to the stockholder welfare maximization version.

From this point onwards, almost all the testing of alternative models of investment that has been undertaken in the literature has been confined to the level of the aggregate economy. One addition to the research agenda has been the estimation of separate models for structures and equipment. In particular, there has been an emphasis on understanding the role of tax policy

[6] See Jorgensen (1971) for a survey of other studies of investment up to the 1970s.

in influencing overall investment expenditures as well as its composition between equipment and structures.

For instance, Bischoff (1971) compared the alternative models of investment for the 1953-1968 period using quarterly data for the U.S. economy; separate regressions were estimated for equipment and structures. In the case of both equipment and structures investment, the modified neoclassical model was found to be the best, followed by the accelerator model.

Clark (1979) also undertook an investigation of the alternative investment models for the 1954-1973 period using quarterly data for the U.S. economy, with separate regressions for equipment and structures. Like the results obtained by Bischoff (1971), Clark found modified neoclassical model followed by the accelerator model to be the best for structures as well as equipment. Clark therefore concluded that output was the primary determinant of non-residential fixed investment in the economy; variables like the rental price of capital services, interest rates, and tax rates proved to be not very helpful.

Likewise, Bernanke et al. (1988) carried out non-nested specification tests of time-series investment models at the level of the economy; separate equations were estimated for equipment and structures using quarterly U.S. data for the 1955-1983 period.[7] The conventional goodness-of-fit statistics indicated that no one model of investment uniformly outperformed all other models. Of the four models, the accelerator and the modified neoclassical model were found to be the best models for equipment investment. In the case of structures investment, Q model was found to be the best. However, when non-nested tests that takes into account serial correlation

[7] One difference between the specifications in Bernanke et al. (1988) and those of Bischoff (1971) and Clarke (1979) was that Bernanke et al. (1988) tested only four models: (i) accelerator; (ii) neoclassical; (iii) modified neoclassical; and (iv) Q. Somewhat surprisingly, they did not test the cash flow model.

in the residuals were performed, the Q model was found to be the best. Also, detailed Monte Carlo evaluations did not turn up any conclusive evidence for any of the competing models of investment.

Empirical testing of the information-theoretic approach to investment began with Fazzari and Athey (1987) and Fazzari et al. (1988). This also marked the revival of panel data econometrics to the study of investment decisions.[8] The information-theoretic approach has really blossomed since then.[9]

What is interesting to note from this discussion is that there has not been any comparison of alternative models of investment based on firm-level data after Elliott's study in 1973. Even in the studies done at the economy-level after 1973, the pure cash flow model has not been tested.[10] On both these counts, this paper differs from the rest of the literature. The choice of the firm as the unit of analysis is also appropriate, given that investment decisions are fundamentally made at the firm-level. More generally, this approach is also consistent with the view in the literature that sees the world as a collection of firms.[11]

It is also somewhat ironic that even after Kuh (1963) demonstrated the appropriateness of the fixed effects approach to the estimation of investment regressions in panel data, it was largely ignored. For instance, Jorgensen and Siebert (1968a, 1968b) largely concentrated on

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[8] As noted by Hsiao (1986), Kuh (1963) can be regarded as the seminal work in panel data econometrics.

[9] See for example the collection of papers in Hubbard (ed.) (1990). See also Hoshi et al. (1991), Oliner and Rudebusch (1993), and others.

[10] While Bischoff (1971) and Clark (1979) tested the cash flow-accelerator model, Bernanke et al. (1988) did not include the cash flow model in any form at all.

[11] See Mueller (1993) for instance.

time-series procedures, believing that the time-structure of investment is the key element. Likewise, Elliott (1973) focussed on cross-section results.[12]

Policy implications

A proper understanding of the determinants of investment is also crucial from the perspective of economic policy. In what follows, the policy implications of the alternative models of investment are discussed briefly.

Since the neoclassical theory of investment regards the cost of capital as the most important determinant, its principal policy recommendation is in terms of tax measures that would lower the cost of capital and therefore stimulate investment.[13] On the other hand, the cash flow theories of investment argue that what matters for investment is the availability of capital rather than the cost of capital. However, the policy implications of two of the variants of the cash flow theory, the managerial and information-theoretic approaches, are quite different.

As noted before, the information-theoretic approach, like the neoclassical theory, is based on the assumption of profit-maximizing behavior by firms. In the information-theoretic view, firms are credit-constrained only because of the asymmetry of information between managers and outside suppliers of finance. The information-theoretic approach therefore implies that funds are invested at rates of return above the shareholder opportunity cost of capital.

On the other hand, managerial theory of investment argues that mangers prefer to use internal finance due to considerations of managerial discretion. Overinvestment of the firm's

[12] The time-series approach of Bischoff (1971), Clark (1979), and Bernanke et al. (1988) are perhaps more justified since they use aggregate rather than disaggregated data.

[13] In fact it is a common practice to use tax-adjusted user cost of capital in empirical estimations of the neoclassical model; likewise, tax-adjusted q ratio is also deployed in estimating the Q model.

resources at rates of return below the shareholder's opportunity cost of capital[14] is a matter of great concern in the managerial theory of the firm. In particular, overinvestment by old, mature firms could displace investment by young, dynamic firms at or above the market discount rate. Therefore, the attendant resource allocation may not be optimal from the point of view of social welfare.[15]

Another implication of the cash flow theories of investment is that since investment is positively related to internal finance, the severity of recessions could get exacerbated. Therefore, countercyclical policies may be helpful. Tax policy also plays a part in the cash flow theories of investment in that they can change the amount of internal finance available firms.

The accelerator theory of investment is basically driven by demand considerations wherein investment depends on the level of output. Therefore, fiscal and monetary policies aimed at a steady increase in output could have a positive effect on investment.

The Q theory of investment also implies significant role for tax policy in influencing investment decisions through modifying the q ratio and strengthening its positive relationship to investment. Summers (1981) has shown the importance of the announcement and timing effects of tax changes on investment using the Q-theoretic framework. While increases in the investment

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[14] See Mueller and Reardon (1993) for recent evidence. Brainard et al. (1980) also found that substantial volume of investment in the U.S. economy had been undertaken below the opportunity cost of capital, which is inconsistent with the predictions of the neoclassical theory.

[15] As noted by Friedman and Laibson (1989), a corporation that is largely dependent on internal finance is not totally insulated from the judgement of the stock market. The market still prices the company's shares, and shareholders seeking improved returns may exert some influence on the firm's management. In addition, if the market places too low a value on the firm's shares, it could become a target for take-overs. However, there are well-known inefficiencies in the corporate governance mechanisms and the market for corporate control.

tax credit or accelerated depreciation stimulate investment, the effects of those increases depend critically on the timing of the announcement and its enactment.

Given these policy implications, it is indeed important to have a proper understanding of the determinants of capital expenditures, especially at the firm-level where these decisions are ultimately made. This is the primary objective of this study and forms the basis for the comparison of the alternative models of investment.

Data and variables

The objective of this paper therefore is to compare the competing models of investment using panel data. In particular, one could question the premise of some recent research that argues that the Q-theoretic approach is the best way to think about investment decisions.[16] This study goes back one step, and re-examines the competing theories of investment using firm-level data. In that sense, this paper is very similar in spirit to that of Kuh (1963), Jorgenson and Siebert (1968a, 1968b), and Elliott (1973), albeit with a bigger sample and for a later time-period. This study is based on the capital expenditure decisions of a panel of 331 U.S. manufacturing firms, taken from Standard and Poor's COMPUSTAT database for the 1972-1990 period. As noted before, this is the first comparison of alternative models of investment after 1973 using firm-level data.

In estimating the neoclassical and Bischoff models, two measures of the opportunity cost of capital--used in turn for computing the user cost of capital--have been used in this paper. In time-series regressions, the real rate of interest--the nominal rate less inflation--is used as the

[16] Chirinko (1993) provides a comprehensive survey of the current state of research on investment theory, with particular emphasis on Q-theoretic models.

opportunity cost of capital. In cross-section regressions, the opportunity cost of capital is proxied by the rate of return on firms belonging to similar risk-classes, following the procedure outlined in Grabowski and Mueller (1972).[17] The q ratio has been computed following the procedure in Salinger and Summers (1983).

II

Time-series estimates (Tables 1, 2, 3, 4, 5, 6, 7)

Traditionally, time-series regression estimates have been viewed as reflecting short-run reactions. For each firm, regressions are run for each model for the 1972-1990 period. Then, a relative ranking of the models for each firm is done, based on adjusted r^2, F-ratio, and the standard error of the regression. The estimation has been done in first differences so as to correct for serial correlation. All the variables have been adjusted for inflation.

Regressions without lagged variables

It may be noted that for the cash flow and Q models, data is available for 18 years; for the accelerator, neoclassical, and Bischoff models, it is 16 years. These different time periods are due to the differences in the specifications of the models. For the neoclassical and the Bischoff models, the opportunity cost of capital was proxied by the real rate of interest.

[17] For each firm, the market rate of return--dividend plus capital gains--is computed for each year during the 1972-90 period. Next, firms are ranked based on the variance in these returns and grouped into risk classes consisting of the contiguous 30 firms. The average rate of return of the 30 stocks in each sample firm's risk class is used as the estimate of the firm's opportunity cost of capital. See Grabowski and Mueller (1972) for more details.

For the whole sample of 331 firms, the ranking of models is as follows: (1) neoclassical model; (2) Bischoff model; (3) cash flow model; (4) accelerator model;[18] and (5) Q model.[19]

Next, each of the models was examined in detail across firms.

(a) Accelerator model: Out of the 331 regressions, there were only 70(21%) with significant F-ratios. Within here, the parameters were significant(5% level or better) in all 70 cases, and the signs were correct for 69 firms.

(b) Neoclassical model: 129(31%) out of the 331 regressions had significant F-ratios. The parameters were significant in 102 cases. The signs were correct in 100 of these regressions.

(c) Bischoff model: 63(19%) out of the 331 regressions had significant F-ratios. The parameters of interest relate to $p_{t-1}Y_t/c_{t-1}$(say b1) and $p_{t-1}Y_{t-1}/c_{t-1}$(say b2). Out of the 63 significant regressions, both b1 and b2 were significant in 31 cases, and were insignificant in 6 cases. In 18 instances, b1 alone was significant, and in 8 cases, b2 alone was significant. In the 18 cases that b1 alone was significant, it had the correct signs (positive) in 17 instances. Likewise, in the 8 cases that b2 alone was significant, the signs were correct in 4 cases and wrong in 4 cases. Out of the 31 cases where both b1 and b2 were significant, the signs were correct in 29 cases and wrong in only two cases.

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[18] It should be noted that even though the change in output is theoretically more appropriate than the level of output for the accelerator model, the latter fared better in empirical specifications, suggesting that businessmen work towards a targeted capital-output ratio. This result is also consistent with the findings of Clark (1979).

[19] Two versions of the Q model were tried; one with capital expenditures (I) as the dependent variable and the other with the ratio of capital expenditures to the replacement cost of capital (I/K) as the dependent variable. The latter fared better in empirical specifications and only these results are shown here.

(d) Cash flow model: 62(19%) of the 331 regressions had significant F-ratios. The parameters were significant in all of the 62 cases. The signs were correct in 57 cases.

(e) Q model: Only 25(8%) of the 331 regressions had significant F-ratios. The parameters were significant in all the 25 cases. The signs were correct in only 9 of these cases.

Based on these results, the ranking of the models now is: (1) neoclassical model; (2) accelerator model; (3) Bischoff model; (4) cash flow model; and (5) Q model. For the most part, this ranking is similar to the earlier ranking, except that the accelerator model is now ranked second (fourth earlier), and the Bischoff model is ranked fourth (second earlier). This ranking can be considered more meaningful than the earlier one in that it is based only on regressions with significant F-ratios. The earlier procedure was much less stringent in that it did not require the individual regressions to be significant (in the F-ratio sense), and merely focussed on their relative ranking, based on adjusted r^2. Therefore, the results based on time-series regressions suggest that at the level of the firm, the primary determinant of capital expenditures is the cost of capital, based here on the real interest rate. i.e., In the short-run, the cost of capital is the most important determinant of capital expenditures.

Regressions with lagged variables

Quite clearly, one of the important determinants that of capital expenditure decisions at the firm-level are the expectations about the future. Given the nature of the data, one cannot capture these ex-ante elements. The next best thing is to relate capital expenditures in the current period to variables of the previous periods. This can be done by running regressions that include lagged variables. The results presented below are based on a one-period lag (one year). Lags of higher order were tried, but turned out to be insignificant.

As before, the ranking of the competing models has been done on the basis of adjusted r^2, F-ratio, and the standard error of the regression. For the total sample of 331 firms, the ranking is as follows: (1) neoclassical; (2) cash flow; (3) Bischoff; (4) accelerator; and (5) Q.

Next, each of these models was examined in detail across firms.

(a) Accelerator model: With the addition of lagged values, 78 regressions (compared to 70 before) are now significant, indicating an overall improvement. i.e., Adding lagged values of changes in output increases the explanatory power of the model. Out of these 78 regressions, both the current and lagged terms are significant in 18 cases. Of these, the signs are correct in 16 cases. In the case of the remaining regressions, the current term alone is significant in 37 cases, and in 20 cases, the lagged term alone is significant. There are 3 cases where neither the current term nor the lagged terms are significant. The signs are correct in almost all of the regressions.

(b) Neoclassical model: The addition of the lagged term brings about a minor decline in the number of significant regressions from 102 to 93. In other words, the addition of the lagged term is not important for the neoclassical model. Out of the 93 regressions, both the current and lagged terms are significant in 29 cases. In the case of the remaining regressions, the current term alone is significant in 51 cases, and the lagged term alone is significant in 9 cases. There are 4 cases where both the current term and the lagged terms are not significant at all. This result also implies that lagged terms are not important for the neoclassical model. This in turn suggests speedy adjustment by firms to changes in cost of capital while undertaking investment. The signs are also correct in most instances.

(c) Bischoff model: With the addition of lagged variables, 76 regressions have significant F-ratios, compared to 63 before. As discussed before, the parameters of interest with regard to the Bischoff model are the ones associated with $p_{t-1}Y_t/c_{t-1}$(say b1) and $p_{t-1}Y_{t-1}/c_{t-1}$(say b2). As in the case of the regression without the lagged term, the b2 term has the correct, negative sign in most of the cases. For instance, in the 2 cases that the current term alone is significant, it is negative in 1 case; out of the 34 cases that the lagged term alone is significant, it is negative in 30 instances. In the 14 regressions that the current and lagged terms for b2 is significant, the signs are correct in 12 cases. Therefore, the addition of lagged terms renders more regressions significant and therefore strengthens the case for the Bischoff model.

(d) Cash flow model: Addition of lagged variables improves the performance of the cash flow model as well. There are now 69 regressions with significant F-ratios, compared to 62 previously. In 16 cases, both the current and lagged terms are significant. In 28 cases, the current term alone is significant, while the lagged term alone is significant in the remaining 23 cases. The signs are also correct in almost all the instances.

(e) Q model: Like all other models (except the neoclassical model), additional lagged variables improve the performance somewhat. The number of significant regressions rises to 46 from 25 before. There are 12 cases where both current and lagged terms are significant; in 13 instances, current term alone is significant and in 20 cases, the lagged term alone is significant. When the signs of the coefficients are examined, the picture is similar. In the 20 times that the lagged term alone is significant, the signs are correct 15 times. Likewise, out of the 13 times that both current and lagged terms are significant, the signs are correct in 10 instances. In the 12 cases that both the current and the lagged terms are significant, the signs of both terms are correct in only 2 cases. In 9 cases, the current term has the wrong sign, while the lagged term has the correct sign. In the remaining one instance, the current term has the right sign and the lagged term the wrong sign. The importance of the lagged q ratio clearly underscores the forward-looking aspect of the q ratios, guided by the stock market, in influencing investment decisions.

On the basis of these results, the ranking of models is: (1) neoclassical; (2) accelerator; (3) Bischoff; (4) cash flow; and (5) Q. With the exception of the neoclassical model, lagged variables improve the fit of the regressions in all cases. This certainly makes intuitive sense since the past levels of output, cash flows, and the q ratio are expected to be important determinants of the capital expenditure decisions at the firm-level. It is also interesting to note that the finding with regard to the superiority of the neoclassical model in time-series regressions is consistent with that of Jorgenson and Siebert (1968a, 1968b).

III

Cross-section estimates (Tables 8, 9, 10, 11, 12)

In the literature, cross-section regressions are viewed as more nearly representing adjusted long-run equilibrium. Cross-section regressions were run for the 1972-1990 period. For each of these years, the regression models were estimated across firms and then the models were ranked for each year based on adjusted r^2, standard error of the regression, and the F-ratio.

Given the way that the models are formulated, only the cash flow and Q models have been estimated for 1972, and all the five models for the years from 1974 to 1990. All the variables have been deflated by total assets to adjust for heteroscadasticity.

When the models are judged on the basis of the F-ratio, all the models turn out to be significant, possibly due to the large sample size (N=331). The ranking of the models based on adjusted r^2, F-ratio, and the standard error of the regression is as follows: (1) cash flow; (2) Bischoff; (3) neoclassical; (4) accelerator; and (5) Q.

Next, these regressions were analyzed in detail in terms of the significance and signs of coefficients. In the case of the cash flow and Q models, the coefficients are significant and have the correct signs in all the cases. In the case of the accelerator model, the coefficients are significant in 12 out of the 17 cases. Out of these 12 cases, the signs are correct in 9 instances. In the case of the neoclassical model, the coefficients are significant in 16 of the 17 cases. The signs are correct in 13 of these 17 cases. In the case of the Bischoff model, there are only eight instances where the parameters associated with both $p_{t-1}Y_t/c_{t-1}$(say b1) and $p_{t-1}Y_{t-1}/c_{t-1}$(say b2) are significant. In all these eight instances, both b1 and b2 have the right signs. In the remaining nine cases, only b1 is significant and the signs are correct in all the nine cases.

Therefore, the revised ranking of the models is: (1) cash flow; (2) neoclassical; (3) accelerator; (4) Q; and (5) Bischoff. It is interesting to note that the finding with regard to the superiority of the cash flow model in cross-section regressions is consistent with that of Elliott (1973).

IV

Fixed effects estimates (Tables 13, 14. 15, 16, 17, 18, 19)

Fixed effects model procedures are designed to take advantage of the panel nature of the data explicitly. They are useful in eliminating the idiosyncratic differences across firms with regard to investment expenditures, i.e., differences that cannot be captured adequately by other independent variables. The primary objective of fixed effects estimation is to control for characteristics that are specific to the firm but invariant over time, over and above elements that are captured through other independent variables. In other words, fixed effects procedures reduce the omitted variable bias.

In the literature, fixed effects are also termed as individual time-invariant and period individual-invariant variables.[20] The individual time-invariant variables are variables that are the same for a given cross-sectional unit (firm) through time, but vary across cross-sectional units. Examples include firm-management, ability, sex, and socioeconomic background variables. The period individual-invariant variables are variables that are the same for all cross-sectional units at a given point in time, but vary through time. Examples include prices, interest rates, and business confidence.

As first step, a pooled Ordinary Least Squares (OLS) regression can be run based on the model

$$Y_{it} = \alpha + \beta X_{it} + u_{it} \qquad (1)$$

Then, a fixed effects model can be done

$$Y_{it} = \alpha_i + \beta X_{it} + u_{it} \qquad (2)$$

where α_i captures the effects that are specific to the firm. Once the two models are estimated, an F-test can be done for testing whether $\alpha_i = \alpha$ or not; i.e., whether fixed firm effects are important or not.

Broadly speaking, there are two equivalent approaches to estimate equation (2): (i) OLS with firm-specific dummies; and (ii) OLS based on deviations from means (for each firm, the mean over time is computed and the deviation taken from this mean). This estimate is known as the Least Squares Dummy Variable (LSDV) estimate, or the within-group estimate. This is

[20] See Hsiao (1986) for a more detailed discussion.

also the time-series estimate, since it only exploits the variation across years.[21] The analysis can be enriched by controlling for year-specific characteristics by inserting year dummies, either in conjunction with firm-specific effects or alone. In what follows, both of these approaches have been carried out.

Fixed versus Random effects: The next issue to consider is fixed versus random effects. One way to think about the difference between fixed and random effects is to view the former as applying only to the cross-sectional units (firms) in the study, and not to additional ones outside the sample. Random effects, or the error components model, is more appropriate if the sampled cross-sectional units are drawn from a larger population.[22]

In the context of this study, it would seem therefore that the random effects estimation may be more appropriate. A general model would be

$$Y_{it} = \alpha + \beta X_{it} + u_i + e_{it} \qquad (3)$$

While α_i is fixed in the fixed effect estimation, it is random $(\alpha + u_i)$ in the random effects model. Consequently, the random effects model has to be estimated using Generalized Least Squares (GLS). The Hausman test (1978) has also been used to see if fixed or random effects is more appropriate for the data.

Tables 13 to 19 show the results of the estimation of fixed effects and random effects models. Model (1) incorporates both firm effects and year effects. Model (2) has only firm effects, and no year effects; model (3) has only year effects, and no firm effects. Therefore,

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[21] It should be noted that while (i) and (ii) are equivalent in terms of parameter estimates, it is not so with regard to r^2. Estimation under (ii) leads to much lower r^2 compared to (i). This is because the deviations from means procedure reduces the model variation(sum of squares). This paper uses approach (i).

[22] See Greene (1994) for a more detailed discussion.

models (1), (2), and (3) represent within group estimates of the fixed effects model. Model (4) has no firm effects and no year effects, and is simply the OLS estimate for the pooled regression. Between group estimates are shown next. GLS(1) and GLS(2) are random effects estimates; while GLS(1) includes year effects, GLS(2) does not have year effects. Model (5) is a regression with only the firm effects on the right hand side. Model (6) is a regression with only the year effects on the right hand side.

Following the practice in the literature, F-ratios have been computed to make inferences from the various models presented. Following Hsiao (1986), model (1) can be viewed as the unrestricted model, and models (2), (3), (4), (5), and (6) as restricted models; in practice, the significance of the particular restriction in question is tested for. This is another way to get at the importance of firm-specific and year-specific effects.

It is interesting to start the discussion of the results with models (5), and (6). As noted before, model (5) is a regression with only firm dummies on the right hand side and model (6) has only year dummies. These models attempt to answer the following question. If only the identities (names) of the firms and time-periods (years) were known, how much of the variation in capital expenditures could be explained?. The surprising result is that firm effects matter a lot, while year effects alone are not so important. For instance, in the case of the model with (I/K) and firm dummies, r^2 is 0.49. Not surprisingly, this level of explanation(value of r^2) is not exceeded by any of the models that do not involve fixed firm effects.

Accelerator model (Table 13)

While year effects together with firm effects turn out to be significant, year effects alone are not significant. Comparison of models (4) and (1) clearly shows the improvement in brought about by the addition of fixed firm and year effects; r^2 increases from 0.73 to 0.89. Given that year effects are not significant, it is no surprise that the parameter estimates from model (1) and model (2) are similar, as are the estimates from models (3), (4), and the between group model. The r^2 values for the GLS models are significantly lower than those for other models. In fact, the results from the Hausman test (based on models (1) and GLS(1)) categorically reject the random effects model.

Neoclassical model I, II (Tables 14, 15)

The basic result is that year effects and firm effects are important, separately as well as together. Again, the improvement in the fit of the regression is considerably better with the addition of fixed firm effects, compared to fixed year effects. When the Hausman test is done, the null hypothesis cannot be rejected implying that the random effects model is more appropriate for the neoclassical model.

Bischoff model I, II (Tables 16, 17)

The results support the Bischoff model, especially the version that uses real interest rate as the opportunity cost of capital. This makes intuitive sense, since the within-group estimates are based on the time-series dimension of the data. When the Hausman test is done, the null hypothesis cannot be rejected implying that the random effects model is more appropriate for the neoclassical model.

Cash flow model (Table 18)

The basic result is that year effects and firm effects are important, separately as well as together. However, year effects are only weakly important, since the improvement in the fit of the regression is significantly better with the addition of fixed firm effects, compared to fixed year effects. When the Hausman test is done, the null hypothesis is rejected and therefore the fixed effects model can be accepted as being more appropriate for the cash flow model.

Q model (Table 19)

Again, year effects and firm effects are important, separately as well as together. The fit of the regression improves significantly with the addition of fixed firm effects, compared to fixed year effects. When the Hausman test is done, the null hypothesis is rejected and therefore the fixed effects model can be accepted as being more appropriate for the Q model.

The ranking of the models based on the above regressions is: (1) cash flow; (2) Bischoff; (3) neoclassical; (4) accelerator; and (5) Q.

V

Conclusions and discussion

The results of the study clearly support an eclèctic approach to the study of capital expenditure decisions at the firm-level.[23] While the time-series analysis ranks the neoclassical model as the best, the cross-section regressions gives the No.1 spot to the cash flow model (Table 20). Likewise, the fixed effects model regressions support the cash flow model and emphasize the prevalence of firm-specific, idiosyncratic differences regarding capital expenditure decisions. This result can also be viewed as vindicating the choice of the firm as the basic unit of analysis in the study. As noted earlier, these findings of the study are consistent with earlier evidence in the literature. If the results from cross-section regressions can be viewed as

[23] This is similar to the result of the pioneering study my Meyer and Kuh (1957) who found that the investment decision is subject to a multiplicity of influences and evidences different behavior under different circumstances and time-periods.

representing the long-run equilibrium, the single-most important determinant of capital expenditures appears to be cash flows.

These results based on the comparison of alternative models of investment are indicative of the relative importance of the determinants of capital expenditures at the firm-level. The results suggest that managers care more about cash flows and cost of capital than the level of output and stock market signals (q ratio). In other words, managerial perceptions of fundamentals facing the firm are more important than market perceptions with regard to capital expenditure decisions at the firm-level.[24]

These results also suggest that contrary to the presumption in the literature, the Q model of investment performs the worst among competing models of investment in empirical specifications, even though it is superior to other models in terms of theoretical elegance. This finding regarding the poor empirical performance of the Q model is consistent with the results of Bischoff (1971), Clark (1979), and Bernanke et al. (1988) based on aggregate data.

Given this overall lackluster performance of the Q model, it would seem that mangers are not primarily guided by the stock market with regard to investment decisions. In other words, the stock market may be a sideshow as far as capital expenditures at the firm-level are concerned. Therefore, these models are consistent with the findings of Morck et al. (1990) and Samuel (1996b) regarding the limited implications of stock market activity for the resource allocation process in the economy. This conclusion then raises two related issues: (i) if the stock market is really a sideshow, market volatility may not really be an issue from the point of view

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[24] See Samuel (1996b) for a more detailed analysis of the relative importance of managerial and market perceptions with regard to capital expenditure decisions at the firm-level. See Blanchard et al. (1993) for a similar analysis at the aggregate level.

of resource allocation in the economy; and (ii) if the stock market is not important for the firm with regard to the investment decision, what are the other implications of stock market activity for the firm.[25]

With regard to developing countries, the testing of investment theories has been confined to accelerator, neoclassical, and cash flow theories of investment.[26] The application of the Q model has been limited, given the rather exacting data requirements for the computation of the Q ratio, following the methodology outlined in Salinger and Summers (1983). In particular, it is difficult to estimate the replacement cost of the firm's capital stock precisely and one has to use the book value instead.

These results are also interesting in the context of ongoing economic reforms in developing countries. Without doubt, increasing private investment by providing appropriate incentives has been perhaps the most critical challenge for these reforming countries and having a proper understanding of the determinants of capital expenditures is a crucial component of this challenge. This has become especially important for countries that are undertaking significant privatization of economic activities and are attempting to reduce the role of the State in economic activities in general and the size of the public investment program in particular.

In addition, the response of investment--especially private investment--to macroeconomic stabilization in general and structural adjustment in particular has been an important issue of

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[25] Samuel (1995) provides a detailed analysis of the financing role of the stock market and Samuel (1996c) provides a detailed analysis of the governance role of the market.

[26] Athey and Laumas (1994) found support for the cash flow theory of investment for India. Using panel data, Harris et al. (1994) and Jaramillo et al. (1993a, 1993b) found support for the cash flow theory of investment for Indonesia and Ecuador respectively. Likewise, Nabi (1989) and Tybout (1983) found support for the cash flow theory for Pakistan and Colombia respectively. Also, Bilsborrow (1977) found support for accelerator and cash flow theories using panel data for manufacturing firms in Colombia.

debate.[27] Research has suggested that investment typically pauses in the wake of adjustment lending and this pause has been attributed to the overall uncertainty that accompanies adjustment lending, which in turn has a negative effect on investment.[28] Therefore, over and above the various factors highlighted by the alternative theories of investment that was discussed earlier, it is necessary to consider uncertainty as an additional factor in the context of developing countries undertaking economic reforms. This issue has also become an important for transitional economies.[29]

A proper appreciation of the underlying factors behind capital expenditure decisions at the firm-level in the case of developing countries has also become important in the context of the recent world-wide interest in emerging markets. Increasingly, capital flows to developing countries have become rapid, though transient at times, in the wake of the constant search for unexploited arbitrage opportunities by global investors, especially institutional investors, on a world-wide basis. From the perspective of portfolio investment as well as foreign direct investment, a proper understanding of the dynamics of investment and economic growth in these emerging markets is essential for sustaining these flows for the long-term.

The results of the study also has some interesting methodological and data-related issues for developing countries. As discussed earlier, this study has shown that the firm rather than

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[27] See Corbo et al. (1992) for a discussion of issues related to structural adjustment and adjustment lending. Pritchett and Summers (1993) also provide a recent overview of the issues.

[28] See Serven and Solimano (1994) for a recent survey of evidence regarding the negative effect of uncertainty on investment. See Dixit and Pindyck (1994) for a more general treatment of issues relating to uncertainty and investment. See also, Chhibber et al. (1992), Bleaney and Greenaway (1993), and Branson and Jayarajah (1995) for discussions of the impact of adjustment on investment.

[29] See World Bank (1996) for an interesting review of the evidence relating to transitional economies.

the industry or the economy is the most appropriate unit of analysis for understanding capital expenditure decisions at the firm-level. In particular, panel data is most useful for distinguishing between alternative models of investment, since it controls for firm-specific and time-specific fixed effects. This in turn is a significant challenge for developing countries, which traditionally have had poor database infrastructure compared to developed countries.

The findings of the study also become interesting in the context of the emerging consensus in the economics profession on looking at economic theory as being capable of explaining economic phenomenon on a global basis, rather than being compartmentalized to address the problems of developing and developed countries separately.[30] This is of course a fundamental departure from the earlier view in the profession and strikes at the very root of a discipline such as development economics. In the new perspective, what distinguishes countries are the conduct of economic policies rather than initial conditions which formed the basis for the earlier notion of different theories being necessary to understand economic phenomenon in developed and developing countries. If one were to go by the emerging view, the findings of this study with regard to the determinants of capital expenditures at the firm-level for a panel of U. S. manufacturing firms could equally be applicable to firms in developing countries.

These findings regarding the relative importance of various factors that underpin the alternative theories of investment are also related to the larger issue of the relationship between financial and real factors in the economy. The evidence presented in this paper regarding the superiority of the cash flow theories of investment in cross-section and fixed effects regressions suggest that financial decisions are indeed closely linked to real decisions in the economy. This

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[30] See Agenor and Montiel (1996) for an interesting exposition of this view.

finding is consistent with the evidence from other studies of sources and uses of funds for firms that have shown internal finance to be the most important source of funds and capital expenditures to be the most important use of funds and therefore a close relationship between real and financial decisions.[31]

Last, but not least, a proper understanding of the determinants of capital expenditures at the firm-level is also crucial for policy making purposes in developing countries. As discussed earlier, the varying nature of policy implications associated with different models of investment implies that policy formulation has to be closely grounded to the underlying theory of investment. This becomes so much more critical, given the current emphasis on reducing the role of the State in economic activity, in the overall context of economic reforms in developing countries, that was noted earlier.

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[31] See Samuel (1995) for instance.

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Appendix I

Investment Models

(I) Neoclassical Model

$$I_t = \alpha + \Sigma\beta_{1s}(\Delta(pY/c))_{t-s}+u_t$$

(II) Modified Neoclassical (Bischoff) Model

$$I_t = \alpha + \Sigma\beta_{1s}(p_{t-s-1}Y_{t-s}/c_{t-s-1}) + \Sigma\beta_{2s}(p_{t-s-1}Y_{t-s-1}/c_{t-s-1}) + u_t$$

(III) Accelerator Model

$$I_t = \alpha + \Sigma\beta_{1s}Y_{t-s} + u_t$$

(IV) Cash flow Model

$$I_t = \alpha + \Sigma\beta_{1s}(CF)_{t-s} + u_t$$

(V) Q Model

$$Log(I_t/K_t) = \alpha + \Sigma\beta_{1s}Q_{t-s} + u_t$$

where I-real capital expenditures, p-price of output, Y-quantity of output, c-user cost of capital ($c=(r+d)p_k$, r-opportunity cost of capital, d-depreciation rate, p_k-investment goods price index. Two measures of r have been used, viz. r_1 and r_2; r_1 follows the methodology outlined in Grabowski and Mueller (1972), and r_2 is the real rate of interest. In cross-section analysis, r_1 was used and in time-series analysis, r_2 was used.); Y-level of output, CF-cashflow (net income+depreciation), Q-Tobin's q ratio, the ratio of market value of the firm to the replacement value of its assets, based on the methodology in Salinger and Summers (1983), and u, the standard error term.

Predictions:
In general, the parameters associated with all the variables in the various models are expected to be positive. However, for the Bischoff model, the parameter associated with the $p_{t-1}Y_{t-1}/c_{t-1}$ term is expected to be negative.

Table 1: Time-series estimates (N=331)
Number of times the ranks is:

	1		2		3		4		5	
	I	II	I	II	I	II	I	II	I	II
Accelerator	44	53	93	90	77	83	81	79	36	26
Neoclassical	126	106	48	55	57	70	54	58	46	42
Bischoff	67	64	80	83	51	48	31	36	102	100
Cashflow	65	66	64	58	66	69	84	90	52	48
Q	30	42	43	45	79	61	80	68	93	115

I-Regressions without lags.
II-Regressions with lags.

Table 2: Time-series estimates (without lags: N=331)
Number of times the left hand side models is better than the right hand side model

	Accelerator	Neoclassical	Bischoff	Cashflow	Q
Accelerator	***	130	187	163	201
Neoclassical	201	***	223	199	237
Bischoff	144	108	***	142	180
Cashflow	168	132	189	***	204
Q	130	94	151	127	***

Note: Based on the methodology in Elliott (1973).

Table 3: Time-series estimates (with lags: N=331)
Number of times the left hand side models is better than the right hand side model

	Accelerator	Neoclassical	Bischoff	Cashflow	Q
Accelerator	***	147	207	170	216
Neoclassical	184	***	216	189	239
Bischoff	124	115	***	139	185
Cashflow	161	142	192	***	211
Q	115	92	146	120	***

Note: Based on the methodology in Elliott (1973).

Table 4: Time-series estimates (without lags: N=331)
Model diagnostics

	Accelerator	Neoclassical	Cashflow	Q
F=0	261	129	269	306
F#0	70	102	62	25
Significance of parameters*				
t#0	70	102	62	25
t=0	0	0	0	
Signs of Parameters				
Correct signs	69	100	57	9
Wrong signs	1	2	5	16

* 5% or better.

Table 5: Time-series estimates (without lags: N=331)
Model diagnostics: Bischoff model

	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$	$p_{t-1}Y_t/c_{t-1}$ & $p_{t-1}Y_{t-1}/c_{t-1}$
Significance of parameters*			
t=0	8	18	6
t#0	18	8	31
Signs for significant parameters			
Correct signs	17	4	29
Wrong signs	1	4	2

* 5% or better.
F ratio is significant for 63 regressions

Table 6: Time-series estimates (with lags: N=331)
Model diagnostics

	Accelerator			Neoclassical			Cashflow			Q		
F=0	253			238			262			285		
F#0	78			93			69			46		
Significance of parameters*	I	II	III	I	II	III	I	II	III	I	II	III
t=0	20	37	3	9	51	4	23	28	2	20	13	1
t#0	37	20	18	51	9	29	28	23	16	13	20	12
Signs of Parameters												
Correct signs	37	19	16	49	9	27	25	23	14	10	15	2
Wrong signs	0	1	**	2	0	**	3	0	**	3	5	**
Current(Yes) ,Lagged(No)	**	**	2	**	**	2	**	**	2	**	**	1
Current(No), Lagged(Yes)	**	**	0	**	**	0	**	**	0	**	**	9

I-Current term only II-Lagged term only III-Current term & Lagged term
* 5% or better

Table 7: Time-series estimates (with lags: N=331)
Model diagnostics: Bischoff model

	Current term only		**Lagged term only**		**Current & Lagged terms**	
Significance of parameters*	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$
t=0	2	36	34	7	15	29
t#0	36	2	7	34	19	14
Signs for parameters						
Correct signs	36	1	6	30	19	12
Wrong signs	0	1	1	4	0	0
Current(Yes), Lagged(No)	***	***	***	***	***	1
Current(No), Lagged(Yes)	***	***	***	***	***	1

* 5% or better
F-ratio is significant for 76 regressions

Table 8: Cross-Section estimates (N=19)
Ranking of models

	Accelerator	Neoclassical	Bischoff	Cashflow	Q
1972				1	2
1973				1	2
1974	4	3	2	1	5
1975	5	3	2	1	4
1976	3	4	2	1	5
1977	4	3	2	1	5
1978	3	4	2	1	5
1979	4	3	2	1	5
1980	5	4	2	1	3
1981	5	3	2	1	4
1982	5	4	2	1	3
1983	4	3	2	1	5
1984	4	3	2	1	5
1985	4	3	1	2	5
1986	3	4	1	2	5
1987	4	3	1	2	5
1988	4	3	1	2	5
1989	5	4	1	2	3
1990	5	4	1	2	3

Table 9: Cross-section estimates (N=19)
Number of times the rank is:

	Accelerator	Neoclassical	Bischoff	Cashflow	Q
1	0	0	6	13	0
2	0	0	11	6	2
3	3	10	0	0	4
4	8	7	0	0	2
5	6	0	0	0	11
Total	17	17	17	19	19

Table 10: Cross-section estimates (N=19)
Number of times the left hand side models is better than the right hand side model

	Accelerator	Neoclassical	Bischoff	Cashflow	Q
Accelerator	***	3	0	0	11
Neoclassical	14	***	0	0	13
Bischoff	17	17	***	6	17
Cashflow	17	17	13	***	19
Q	6	4	0	0	***

Note: Based on the methodology in Elliott (1973).

Table 11: Cross-Section estimates
Model diagnostics

	Accelerator	Neoclassical	Cashflow	Q
N	17	17	19	19
F=0	0	0	0	0
F#0	17	17	19	19
Significance of parameters*				
t#0	12	16	19	19
t=0	5	1	0	0
Signs of Parameters				
Correct signs	9	13	19	19
Wrong signs	3	3	0	0

* 5% or better

Table 12: Cross-Section estimates (N=17)
Model diagnostics: Bischoff model

	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$	$p_{t-1}Y_t/c_{t-1}$&$p_{t-1}Y_{t-1}/c_{t-1}$
Significance of parameters*			
t=0	0	9	0
t#0	9	0	8
Signs for significant parameters			
Correct signs	9	***	8
Wrong signs	0	***	0

Note: F ratio is significant for all 17 regressions
* 5% or better

Table 13: Accelerator model

	ΔY	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.055* (37.31)	Yes	Yes	0.891	149.43	131.37*
Model(2)	0.055* (38.77)	Yes	No	0.890	149.82	137.26*
Model(3)	0.079* (128.15)	No	Yes	0.735	226.03	916.32*
Model(4)	0.079* (128.29)	No	No	0.734	226.12	1648.29*
Between Group	0.080* (39.54)	***	***	0.826	167.67	1563.61*
GLS(1)	0.065* (55.20)	***	No	0.338	152.30	3046.54*
GLS(2)	0.065 (54.24)	***	Yes	0.341	151.97	172.33*
Model(5)	***	Yes	No	0.859	166.91	109.96*
Model(6)	***	No	Yes	0.004	432.51	1.26

Note: t-statistics are in parentheses; * significant at 1% level; S.E.R.-Standard Error of Regression

Table 14: Neoclassical model I

	$\Delta(p_tY_t/c_t)$	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.006* (14.16)	Yes	Yes	0.867	166.98	98.94*
Model(2)	0.005* (13.90)	Yes	No	0.864	168.71	101.23*
Model(3)	0.015* (15.23)	No	Yes	0.043	434.19	14.72*
Model(4)	0.014* (14.82)	No	No	0.037	434.73	219.68*
Between Group	0.265* (19.04)	***	***	0.523	277.38	362.58*
GLS(1)	0.006* (13.82)	***	No	0.033	177.46	190.87*
GLS(2)	0.006* (14.07)	***	Yes	0.049	175.92	18.17*

Table 15: Neoclassical model II

	$\Delta(p_tY_t/c_t)$	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.063* (19.43)	Yes	Yes	0.871	164.34	102.63*
Model(2)	0.063* (19.60)	Yes	No	0.868	165.85	105.30*
Model(3)	0.242* (32.81)	No	Yes	0.164	405.83	64.56*
Model(4)	0.238* (32.59)	No	No	0.159	406.42	1061.90*
Between Group	1.272* (34.09)	***	***	0.779	188.90	1162.20*
GLS(1)	0.073* (20.45)	***	No	0.069	185.24	418.11*
GLS(2)	0.073* (20.32)	***	Yes	0.081	184.02	30.25*

Note: t-statistics are in parentheses; * significant at 1% level; S.E.R.-Standard Error of Regression Neoclassical I uses Grabowski-Mueller (1972) measure of cost of capital; neoclassical II uses the real rate of interest as the cost of capital.

Table 16: Bischoff model I

	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.008* (12.12)	-0.006* (-8.85)	Yes	Yes	0.867	167.15	98.42*
Model(2)	0.008* (11.95)	-0.006* (-8.88)	Yes	No	0.863	168.92	100.63*
Model(3)	0.017* (14.38)	-0.005* (-4.36)	No	Yes	0.586	285.56	440.88*
Model(4)	0.017* (14.65)	-0.005* (-4.13)	No	No	0.579	287.43	3872.08*
Between Group	0.025* (0.98)	-0.013 (-0.49)	***	***	0.705	217.98	395.91*
GLS(1)	0.011* (15.49)	-0.006* (-8.20)	***	No	0.103	177.34	322.97*
GLS(2)	0.011* (15.75)	-0.006* (-8.21)	***	Yes	0.122	175.43	44.42*

Table 17: Bischoff model II

	$p_{t-1}Y_t/c_{t-1}$	$p_{t-1}Y_{t-1}/c_{t-1}$	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.044* (14.74)	-0.005** (-1.64)	Yes	Yes	0.884	155.93	115.35*
Model(2)	0.043* (14.61)	-0.003 (-1.04)	Yes	No	0.883	156.43	120.00*
Model(3)	0.064* (15.04)	-0.002 (-0.54)	No	Yes	0.743	225.06	899.81*
Model(4)	0.062* (14.79)	-0.0004 (-0.08)	No	No	0.742	225.17	8079.11*
Between Group	0.226** (2.23)	-0.168 (-1.62)	***	***	0.839	161.39	857.36*
GLS(1)	0.051* (17.14)	0.0003 (0.09)	***	No	0.343	159.28	1470.12*
GLS(2)	0.053* (17.42)	-0.002 (-0.47)	***	Yes	0.346	158.93	166.35*

Note: t-statistics are in parentheses; * significant at 1% level; ** significant at 5% level; S.E.R.-Standard Error of Regression
Bischoff I uses Grabowski-Mueller (1972) measure of cost of capital; Bischoff II uses the real rate of interest as the cost of capital.

Table 18: Cashflow model

	Cash flow	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.380* (33.86)	Yes	Yes	0.885	151.10	130.69*
Model(2)	0.389* (35.20)	Yes	No	0.883	151.87	136.16*
Model(3)	0.708* (184.42)	No	Yes	0.845	170.63	1797.64*
Model(4)	0.707* (184.08)	No	No	0.844	171.17	33884.43*
Between Group	0.741* (112.78)	***	***	0.975	63.86	12718.38*
GLS(1)	0.649* (108.73)	***	No	0.653	185.24	418.11*
GLS(2)	0.650* (108.63)	***	Yes	0.655	160.17	629.71*

Table 19: Q model

	Q	Firm effects	Year effects	R^2	S.E.R.	F
Model(1)	0.057* (11.41)	Yes	Yes	0.517	0.52	18.19*
Model(2)	0.048* (10.14)	Yes	No	0.502	0.52	18.17*
Model(3)	0.117* (24.26)	No	Yes	0.097	0.69	35.48*
Model(4)	0.109* (23.03)	No	No	0.078	0.70	530.17*
Between Group	0.184* (9.09)	***	***	0.198	0.46	82.58*
GLS(1)	0.056* (11.92)	***	No	0.022	0.53	142.05*
GLS(2)	0.065* (13.26)	***	Yes	0.047	0.52	17.14*
Model(5)	***	Yes	No	0.494	0.53	17.61*
Model(6)	***	No	Yes	0.012	0.72	4.34*

Note: t-statistics are in parentheses; * significant at 1% level; S.E.R.-Standard Error of Regression

Table 20:Ranking of Investment models

	Accelerator	Neoclassical	Bischoff	Cashflow	Q
Time-series (no lags)	4	1	2	3	5
Time-series (with lags)	4	1	3	2	5
Cross-section	4	3	2	1	5
Fixed effects(with firm and year effects)	4	3	2	1	5
Between group	4	3	2	1	5
Pooled regressions	4	3	2	1	5
GLS(with year effects)	5	3	2	1	4

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